GEORGIA INSTITUTE OF TECHNOLOGY **OFFICE OF CONTRACT ADMINISTRATION**

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. A-3641 GTRI/~~GIT~~ DATE 9 /8 /83

Project Director: John Adams ~~School~~/Lab TAL-AT

Sponsor: Duramatic Products, Inc.
Glennville, GA 30427

Type Agreement: Research Project Agreement dtd. 8/31/83

Award Period: From 8/31/83 To 11/30/83 (Performance) ______ (Reports)

Sponsor Amount: This Change / Total to Date

Estimated: $ ______ $ ______

Funded: $ ______ $ 13,907

Cost Sharing Amount: $ ______ Cost Sharing No: ______

Title: Productivity Improvement Study Through the Application of Alternative Blade Materials Utilization

ADMINISTRATIVE DATA

OCA Contact John W. Burdette x4820

1) Sponsor Technical Contact:

Mr. Dennis Lamb
General Manager
Duramatic Products, Inc.
Rotary Equipment Division
P. O. Box 405
Glennville, GA 30427

2) Sponsor Admin/Contractual Matters:

Same as 1)

Defense Priority Rating: N/A

Military Security Classification: N/A
(or) Company/Industrial Proprietary: N/A

RESTRICTIONS

See Attached ------ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with None proposed

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SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date December 22,1983

ɔject No. A-3641   ~~School~~/Lab TAL

ːludes Subproject No.(s) N/A

ɔject Director(s) John Adams   GTRI / ~~XXXX~~

ɔnsor Duramatic Products, Inc.

le "Productivity Improvement Study Through the Application of Alternative Blade Materials Utilization"

ective Completion Date: 11/30/83 (Performance) (Reports)

ınt/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

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Productivity Improvement Study Through the Application of Alternative Blade Materials Utilization

submitted to

Duramatic Products, Inc.

prepared by

John C. Adams, P.E.
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Georgia Institute of Technology
Engineering Experiment Station
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Atlanta, Georgia 30332

November 1983

Table of Contents

I. INTRODUCTION

This report presents the results of a study investigating the feasibility of utilizing alternative materials in the production of lawn mower blades at Duramatic Corporation. The study was prompted by the problems currently encountered by Duramatic related to blade warpage during the heat treatment process. Carbon steel blades are currently austempered to achieve the desired material properties of surface hardness and ductility. Finished blades must exhibit a Rockwell "C" hardness of 38-42 and yet still be ductile enough to pass a 90° bend test. While blades with appropriate properties can be produced, the study was undertaken to determine if a more suitable material could be located which would reduce or completely eliminate blade warpage and the associated straightening operation. Also, a general simplification of the heat treatment process was sought.

The austempering process is a necessary component of the blade manufacturing process, but by its nature is very energy intensive. Furthermore, any significant blade warpage adds to the manufacturing cost because the straightening process is heavily labor intensive. Any reduction in the energy consumption of the austempering process and/or its associated blade warpage offers the potential for significantly reducing manufacturing cost through improved plant productivity.

The business environment in which Duramatic operates places constraints on materials that must be considered. For instance, the materials evaluated in this study were restricted to carbon or alloy steels, because non-metallic materials such as plastics or composites have encountered poor customer acceptance in the marketplace. Since Duramatic Products supplies blades primarily for the replacement blade market, management stated that they did not feel they could successfully merchandise non-metallic blades in the aftermarket. Of the steels that could be considered as replacement candidates, each had to be suitable for use in the existing production processes of Duramatic, to reduce production modification costs. Physical properties, such as thickness, width, and machinability, therefore, had to be for the most part similar to the current materials in use. The selected material, following heat treatment, also had to be able to demonstrate surface hardness and ductility in the range of the current steels to meet product specifications.

The alternate blade materials study undertaken consisted of two major tasks: a literature search and an industrial survey of metal fabricators and steel producers. The purpose of the literature search was to determine the state of the art in heat treatment, paying particular attention to the metals utilized, treatment process operating parameters employed, problems encountered (such as distortion and warpage) and steps taken to correct any difficulties. It was expected that the literature search would provide a starting point for further exploratory study. Articles found in the search would also provide insight into the appropriateness of current manufacturing procedures.

The second component of the study was a survey of metal fabricators and steel producers. It was anticipated that contacting other metal fabricators would yield more data on current material utilization, process parameters, and problems encountered in similar situations. Steel producers were also contacted to develop information on the types of steels available that are suitable for this application, and the associated costs of these materials.

II. LITERATURE SEARCH

The initial element of the study was a literature search to document current practices in strip metal forming. The literature search was accomplished using computerized access to available publication listings. The keywords used in the search were "austempering," "dimensional control," "steel," and combinations of these words. The main publication file consulted was the metal index file (METADEX), formulated by the American Society of Metals. Articles from the years 1976-1983 only were selected. The given descriptors located approximately 30 (see Appendix I) articles from which approximately 10 were selected for relevance to this study.

Significant Findings Obtained from the Literature Search

Review of the pertinent articles on austempering revealed the following major advantages and limitations to the process.

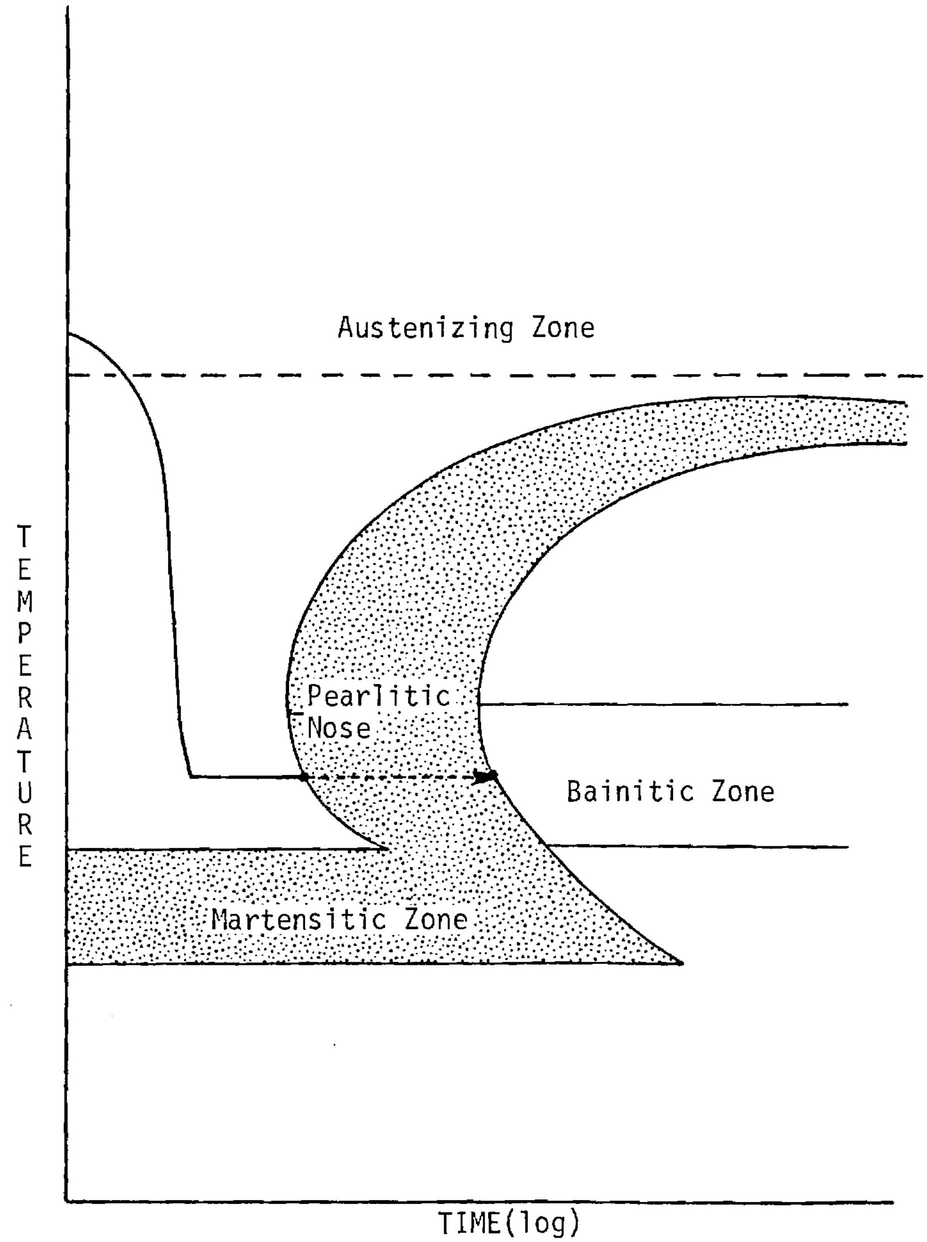
Major Advantages:

- Higher ductility at high hardness
- Less heat treating distortion
- Less heat treating breakage
- High fatigue life.

Major Limitations:

- Section size
- Carbon level of the specified steel.

When considering a grade of steel for austempering, a number of factors must be considered. For example, there is a definite thickness effect; as the material hardness increases, section size can also be increased. The maximum cross sections obtainable correspond to center cooling rates that just miss the pearlitic nose of the material "S" curves (see Figure I) for quenching into a fused bath held at 600^{o}F. Values for typical steels are presented in Table I. The ductility and hardness levels are limited by the carbon level of



AUSTEMPERING PROCESS
FIGURE I

TABLE I[2]

SAE Steel Type	Carbon Content %	Maximum Cross Section (inches)	Maximum Hardness Rockwell "C"
1050	0.48-0.55	0.125	48/50
1060	0.55-0.65	0.250	48/50
1062	0.58-0.68	0.250	51/54
1065	0.60-0.70	0.187	50/54
1080	0.75-0.88	0.200	55/57

the material.[1] In addition to the cross section factor, the configuration of the part and its adaptability to processing in the available equipment must be considered. Parts that are long and slender, like lawn mower blades, might require vertical suspension to minimize or avoid distortion.[2]

The hardness and ductility obtained with austempering have caused it to find application in a number of industrial applications. Rockwell "C" hardnesses in the range of 30-47 can typically be achieved.[3] Applications include:

- Pistol Parts
- Seat Belt Hardware
- Wrench Bodies
- Harrow Disks
- Office Machine Parts
- Diesel Engine Cylinder Liners
- Other situations requiring high hardness, toughness, and resistance to brittle failure.

Seat belt hardware is made from SAE 1055 steel tempered to Rockwell "C" 42-43.[4] Austempering produces a part that will bend but not break under shock loading. Austempering is the choice for cylinder liners because acceptable material properties can be obtained with a minimum of distortion. One firm is able to produce treated sleeves with 1/8 inch wall thickness having distortion ranging from 0.001 to 0.010 inch. The former tempering method yielded distortion in the range of 0.010 to 0.020 inch.[4]

The hardness obtained in an austempering operation is the result of the composition of the material used and the severity of the quench. Several different quench mediums are used in industrial heat treating operations with common ones being water, oil, and molten salt. Water is a convenient quench medium, but because of the high heat removal rates possible, it tends to yield a greater degree of distortion and cracking. Moreover, since water often forms a vapor blanket around the quench piece and prevents effective heat dissipation, it can cause a part to have soft spots. Oil baths have inherent problems including stability and fire hazards and typically give lower hardnesses since the heat extraction rates are lower. Molten salt overcomes the critical problems of distortion and cracking because the cooling rate is lower, yet molten salt still provides adequate hardness.(5) In situations where minimum distortion is a prime consideration, austempering should be done at the lowest possible temperature, and quenching at the highest temperature possible to meet the necessary hardness.(1)

A situation similar to that at Duramatic was found in an industrial saw blade manufacturing operation.(5) The company produced blades 42-1/8" long by 3/16" thick from A151 1080 steel. Production requirements called for a Rockwell "C" hardness 38-42 and a blade straightening operation following heat treatment. Because of the blade design configuration (length 223 times the thickness), severe quenches such as water or oil could not be considered due to the warpage that would result. An austempering process was selected as the appropriate treatment to yield properties consistent with the requirements. Even when treated at the minimum temperature differential, however, the blades had some tendency to warp. A process modification was made, therefore, to achieve the desired straightness.

The blades were placed in a 1600°F austenitizing bath for 20 minutes followed by a 20 minute quench at 650°F. The blades were then air cooled and at this point, they had a Rockwell "C" hardness of 50-52 which was harder than required. However, some of this hardness was lost in the drawing operation which followed. This final step of the heat treating operation involved placing groups of 30-40 blades in a press jig, tightened down until they were pressed flat and then drawing them in this fixture at 800°F for 3 hours before being air cooled. After drawing, the blades were straight and had a Rockwell "C" hardness of 40-41. The final tempering step served to:

- Stabilize the carbide structure
- Relieve stresses that resulted from the austenitic transformation
- Improve ductility with a slight loss of hardness.

The 800°F drawing temperature was high enough to soften the blades for straightening, but not sufficiently high to destroy the bainitic microstructure and impair the blade hardness.(6)

To expand on the information found in the literature search, Dr. John T. Berry of the Mechanical Engineering School at Georgia Tech, an expert in metalurgy, was consulted to determine if any aspects of the warpage problem had been neglected. He indicated that the random nature and the minor degree of warpage occurring at Duramatic are related to the heat treatment process itself and not to the material being treated. He added that the cause of warpage may be attributable to several different factors surrounding heat treating. These include:

- Lack of a stress relief step prior to heat treatment
- Level of cold work of the strip supply steel
- Residual stresses resulting from the uncoiling of small diameter strip steel coils
- Homogeneity of the strip
- Actual austempering conditions: salt conditions, temperature, agitation.

The literature survey, therefore, revealed that a variety of steels were suitable for lawn mower blade manufacturing by austempering. There was no indication, however, of any correlation between the specific material treated and the degree of induced warpage. Moreover, evidence strongly suggested that most problems with dimensional control are related to the particular heat treatment process, specifically the severity of the quenching operation.

III. INDUSTRIAL SURVEY OF METAL FABRICATORS AND SUPPLIERS

Following the completion of the literature review, a survey of steel suppliers and fabricators was conducted. The fact that the literature indicated a limited connection between the degree of blade warpage and the specific material utilized, led us to believe that an industrial survey would shed further light on the current trends in austempering and recent introduction of improved steels and alloys.

A telephone survey of approximately 12 manufacturers and suppliers for potential steel strip stock was performed. This was conducted to acquire information on not only price and availability, but also to learn what types of material they recommend to meet the constraints and why. The intent was to determine what types of steel were commercially available and possibly what types were supplied to other blade manufacturers. Also, it was desirable to learn what information existed concerning austempering and dimensional control.

Below is a composite of the major points of the survey as they relate to alternative steels and dimensional control of final products. Those responses that were not pertinent to the study were excluded. The survey was conducted with domestic manufacturers and suppliers only. Appendix II contains the full address and contact person for the firms surveyed.

(I) Sharon Steel

The majority of blade manufacturers they deal with purchase 1566 steel. This is a high manganese steel that is hot rolled and normalized. Normalization, which costs 1-2 cents/pound, is required to relieve the supplier of any possible product liability. Dimensional control problems and low hardness is a consequence of utilizing steels with too low a carbon content. Steels with less than 0.50% Carbon require a severe quench frequently still resulting in inadequate hardness and warpage problems. Boron steels enable the use of lower carbon steel, but no lower than 10B38 for Rockwell "C" of 38-42. There is no apparent advantage in using boron steels because costs are currently more favorable for plain carbon and high manganese steels. Also, heat treated boron steels are more difficult to properly austemper.

Price Quote:

10B38	- $36.45/100#	(40,000# minimum order)
1566	- $35.75/100#	" " "
1040	- $34.75/100#	" " "

(II) Manufacturing Services, Inc.

Previous blade manufacturers they serviced used 1066, 1065, 1050, 1045, and 10B38. The higher carbon steels need good speroidized carbon to insure that the blades will pass ductility requirements. They believe that adequate carbon, hot roll is available for $28.00-$29.00/100#. Dimensional control problems were not expressed in the past. Possible reasons for excess warpage may be:

(A) Steel carbon content too low, thus severe quench

(B) Austemper salt bath problems:

(1) Poor agitation

(2) Poor temperature control

(3) Salt quality inadequate

(C) Excessive slack quench

(D) Spacing between blades on rack: less than 2.5".

(III) Rex of Georgia, Inc.

7-4PH steel available, which gives excellent dimensional control with Rockwell "C" hardness of 40-45. It is a age hardening steel that is purchased in "condition A" worked and hardened without austempering by a aging process (at elevated temperature). It is expensive material and is expected to be cost prohibitive for blade manufacture. No cost data was provided.

(IV) Hanna Steel Corp.

This source is a distributor of various types of steel. They have supplied 1055 hot roll for lawn mower blade manufacture. No prices were quoted.

(V) Worthington Steel

This company is currently a supplier for Duramatic and considers the heat treatment process to be the primary factor in dimensional control. The boron steels enable the use of lower carbon content, such as 10B40 and are essentially equivalent to 1060 in the context of blade manufacture. In contradiction to source (I), they indicated that boron steels move the pearlitic nose to the right, thus making it more forgiving to slack quench. Some success has been made in using 10B30, but you should expect the severe quench to cause distortion. In utilizing 1566 steel, ductility will be the greatest problem. Improving dimensional stability can be accomplished by reducing the severity of the heat treatment (by using higher carbon steel) and by reducing cold work stresses prior to austemper (utilizing normalized steel or stress relieving in a jig). Price quote given was $31.50-$32.00/100# (40,000# lot) for high carbon with a 5% increase for boron steel.

(VI) Steel Strip Sales

Boron offsets carbon content in steel for many applications. The most commonly purchased steel for blade manufacture is 10B38. Other steels purchased for this product are 1050 (lower quality product), 1060 and 1065.

Price Quote for a 40,000# lot is:

1050 - $30.75/100# (not normalized)
1065 - $31.50/100# " "
10B38 - $31.25/100# " "

(VII) Scot, Inc.

Steel purchases should be made for not only final product specifications, but also for the specific type of heat treatment equipment. 1566 high carbon and high manganese are frequently sold to blade manufacturers. Also, 1040-1060 is commonly used. All steels supplied are heat treated and normalized. 10B38 is also sold, but heat treatment requires very tight control. All prices quoted are for a 40,000# lot minimum purchase with heat treatment and normalization.

Price Quote:

1566 - $35.75/100#

1040 - $34.75/100#

10B38 - $36.45/100#

(VIII) U.S. Steel

Most of the blade manufacturers purchasing from them use the boron steels. Fundamental problem with distortion stability is agitation of the salt bath. Hot roll stock is also preferable to minimize internal stresses prior to austempering. Costs and recommended materials were not supplied.

Summarizing the above information, most metalurgists share similar opinions on the underlying statement that the blade steels should have as little residual stresses (prior to austempering) as possible. This may be accomplished by utilizing hot roll stock or some types of stress relief before austempering. Further, most felt that the severity of the quench required for lower carbon steels intensifies the warpage problems. Finally, many of the steels being supplied to other blade manufacturers are the same as that used by Duramatic.

IV. RESULTS AND ANALYSIS

After completing the data collection portion of the study, the final step in the project was to analyze the data and formulate specific recommendations. In the contract work statement three categories of potential substitute steels were envisioned:

- Those not requiring heat treatment
- Those utilizing Duramatic's existing processes, but adding pre-treatment or post-treatment operations
- Those utilizing Duramatic's existing processes.

Considering each category separately was begun by examining steel materials that would not require heat treatment, but could still meet the required material specifications. Having an outside firm treat the stock before delivery is not considered an option here since this would yield an extremely hard material requiring specialized equipment to fabricate. The only alternate material that comes close to this definition is age hardened steel which requires heat treatment, but not of the severity of austempering. Acceptable hardness with reduced warpage could be possible, but the high cost of this material removes it from serious consideration.

Next, those materials that could prove acceptable by using additional processing steps to reduce the severity of any heat induced warpage were examined. In reality, changes of this sort are not associated with any particular material, but rather are manifest as changes in the process. Two process changes that could ameliorate the warpage situation were presented in earlier sections:

- Stress relief before austempering
- Drawing (tempering) following the quench.

All cold working of the strip stock either at the steel manufacturer or the plant renders residual stresses. If these stresses are not removed by pre-heating prior to austempering, the austenitic high temperature salt bath will consequently serve this purpose. However, at this time, the blades are loosely supported on a rack, thus enabling dimensional changes or warpage to occur due to the uneven distribution of stresses acting on the blade surface area. Minimizing the cold working along with utilizing well normalized strip steel could reduce warpage problems.

Another consideration is that, typically, stress relieving by pre-heat is performed in an oven or bath held at 1200°F. By specifying normalized strip steel that is stress relieved at the factory and minimizing the cold working on the material, inherent residual stresses and consequently the warpage could be reduced. Further, drawing the blades following quench can eliminate quench-induced warpage as observed in the study on the manufacture of saw blades referred to earlier in the literature search section. In that instance, the parts were treated to a higher hardness than required and tempered in a press-jig under tension, thereby reducing hardness to the correct level and eliminating warpage. While these additional operations either singularly or jointly may eradicate warpage, there will be a significant associated cost. The cost will not only be in terms of the additional equipment and energy necessary, but also the additional labor and time required. Thus, while these process modifications may offer a solution to the problem, they are not in the form of a material change as originally envisioned, but a process modification.

The final category of materials to be evaluated were those which could be used with the existing Duramatic process equipment, yet furnish the desired final quality constraints. As expected, materials found to fit this category are found to overlap considerably with those currently being used at Duramatic. Characteristics that are expected to improve final quality and/or eliminate extensive straightening are listed below:

(A) Normalized, hot rolled carbon steels of 1050-1065 grade (well spheroidized)

(B) Boron steels of carbon content equal to or above 10B38 grade

(C) High manganese steels such as 1566.

High grade alloy steels (series 4000, 4100, 4300, 4600, 4700, 4800, 5000, 5100, 6100, 8600, etc.) were eliminated early in the study because they were deemed too expensive in light of the cheaper substitutes listed above. Without including cost constraints, alloy steels like the 5100, 1300, and 4000 series would offer good dimensional control characteristics. The purpose of alloying elements in steels is to increase the hardenability of the material. Alloy elements increases the depth of hardness which makes possible the treating of larger sections than with carbon steel. Alloy steels can typically achieve the same degree of hardness as carbon steels with a less severe quench, thus reducing distortion and the tendency to quench crack. At a given carbon content, the cheapest means of increasing hardness is by increasing the manganese content.[5] Boron is another alloying element that is both potent and economical. A very small addition of boron (approximately 0.001%) has a powerful effect on hardenability.

Since no previously untried materials, except the 1500 series, were found to be reasonable candidates, it appears the problems encountered must be attributed to other causes, such as the purchase of lower quality material than required, upsets in the heat treat operation, or a combination of both. To address the possible problem of material quality, it is recommended that normalized material be considered. Although higher in cost, normalized steel, especially in the 1000 series, will present uniform properties that are relatively free of residual stresses from the factory. The added cost of normalizing can be as much as 4 cents/pound. This compares favorably to the reported cost for blade straightening (based only on labor) on the order of 8-10 cents/pound of steel. In some instances, firms perform in-house normalizing, but this is deemed inappropriate for Duramatic because the large capital outlay for additional equipment would not be cost effective.

A final consideration to be examined is that some degree of warpage is likely induced during the in-plant heat treating operation. As discussed earlier, the quench process is by nature one that can create large thermal stresses. The greater the temperature difference between the high temperature bath and the quench bath, the greater the thermal stresses and thus warpage potential. Using higher carbon content or alloy materials reduces the hardening necessary and thus, the severity of the quench.

In summary, the steels currently being used (10B38, 1050, 1060, and 1065) appear the most economical feedstock. Problems associated with excess dimensional change during heat treatment are likely to be the result of one (or a combination) of the following:

- o Poor raw strip steel uniformity and quality
- o Lack of normalized or adequately normalized strip
- o Excessive cold working in existing processes (as in unrolling the strip coils)
- o Problems in the heat treatment operation
  - Temperature control
  - Salt quality
  - Bath agitation
  - Slack cooling
  - Blade positioning on the rack.

Identification of the major contributors to warpage may be performed by following marked test blades through the existing process. Studying the test blades after each step of the process will indicate if such factors as the supply strip stock, cold working in the forming operations, or the actual heat treating process is the main culprit.

The most critical analysis is in tracking the heat treatment operation. Here, thermocouples attached to a number of blades in a rack (and at different locations on the blades) will indicate any uneven heating, slack cooling, or quenching that may cause the majority of the dimensional control problems.

The identification and resolution of such problems may enable Duramatic to utilize lower carbon or carbon/boron steels with satisfactory final product quality. This offers a savings in not only straightening costs, but also in raw material costs. Current efforts to utilize 10B30 may be fully developed so that additional cost savings may be achieved.

References

1. Metals Handbook, Property and Selection, Vol. I, American Society of Metals, 8th ed., 1977.

2. R. L. Suffredini, "Factors Affecting Austempering," Heat Treating, January 1980.

3. Author Unknown, "Austempered Strip Eliminates Heat Treatment," Metal Working Production, March 1966.

4. Q. D. Mehrkan, "Salt Bath Austempering and Martempering," Machinery, June 1969.

5. Metals Handbook, Heat Treating, Cleaning, and Finishing, Vol. II, American Society of Metals, 7th ed., 1976.

6. W. L. Demerest, "Hardening of Industrial Saw Blades without Distortion," Industrial Heating, July 1981.

Appendices

Appendix I

Recent Articles Considered for Reference

1. Salt Bath Austempering and Martempering
   Mehrkam, Quentin D.

2. Zero Change in Length at the Hardening and Austempering of Steel
   Pietikainen, Juha

3. Bright Heat Treating Carbon Steel Strip Using a Lead Quench

4. Some Consideration on Heat Treatment of Steel for Service Reliability

5. Hardening of Industrial Saw Blades Without Distortion

6. Bright Hardening and Tempering of Steel Strip

7. Factors Influencing Austempering

8. Austemper Answer

9. The Effect of Production Conditions on the Stress Corrosion Resistance of High Strength Austempered Reinforcing Steel 3-8 mm in Diameter

10. Salt Reclamation Systems in Austempering Furnaces

11. Robots Lend a Hand in a New Ausforming Line

12. Process of Austempering and its Applications

13. Austempering Improves Retaining Rings

14. Properties and Workability of Austempered Steel Strips

15. Austempering as a Finishing Technique

16. Austempering Alters Brittle Failure

17. Primer on Forging and Heat Treating

18. Salt Bath Austempering and Martempering

19. Austempering of Carbon Steel Bars Over 5 mm in Diameter

20. Forming Hardened Strip Steel

21. Friction Hardening Gives Superhard Steels

22. Austempering Becomes a Flow Process in Conveyorized Salt Baths

23. Austempering Seat Belt Hardware in Salt Baths

24. A Guide to Heat Treating

25. Isothermal Heat-Treatement of Plough and Harrow Discs

26. For Spring Parts--Which Hardening Process

27. Austempered Strip Eliminates Heat Treatment

28. Possibilities and Future of Mechanical Heat--Treatment of Tubes

29. Feasibility of Austempering Pipe

30. Structure and Strength of Some Ausformed Steels

31. LIttle Known Facts of Treating Metal by Heat

32. Some Consideration on Heat Treatment of Steel for Service Reliability

Appendix II

Firms and Contacts Offering Pertinent Information

I Sharon Steel
Customer Technical Services
P.O. Box 291-T
Sharon, PA
Contact: Scott Williams
(216) 448-4011

II Manufacturing Services, Inc.
P.O. Box 1065
Swainsboro, GA 30401
Contact: Richard Brown
(912) 237-8994

III Rex of Georgia
P.O. Box 198
Conyers, GA 30207
Contact: Craig Lorey
(404) 922-3954

IV Hanna Steel Corp.
Service Center
P.O. Box 558
Fairfield, AL 35064
Contact: John Montgomery
(205) 780-1111
(404) 922-7676

V Worthington Steel
1205 Dearborn Drive
Columbus, SC 43085
Contact: Tom Zimmerman
(614) 438-3000

VI Steel Strip Sales
3 Dillie Road
Cleveland, OH 44117
Contact: Tom Wilson
(216) 531-8478

VII Scot, Inc.
3169 Holcom Bridge Road
Norcross, GA 30071
Contact: Paul Danilove
(404) 449-9075

VIII U.S. Steel
P.O. Box 639
Newnan, GA 30264
Contact: Joe Sumpter
(404) 253-7176